Cryogenic Performance of Field-Effect Transistors and Amplifiers Based on Selective Area Grown InAs Nanowires

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Efforts to achieve large-scale electronic quantum circuits motivate the search for the optimal scalable and reproducible platform for mesoscopic devices. Selective area growth (SAG) of III-V semiconductor nanowires (NWs) offers scalability and planar geometries compatible with standard processing techniques [1,2]. However, interactions with the substrate may influence the transport characteristics [3]. We present a detailed analysis of InAs SAG NW field-effect transistors (FETs) and explore their performance in amplifier circuits at cryogenic conditions. NWs are grown using molecular beam epitaxy (Fig. 1a) and NWFETs are fabricated directly on the growth substrate as part of a NW multiplexer circuit [4] (Fig 1b,c). We systematically consider the ON/OFF ratio, threshold voltage, inverse subthreshold slope, density of interfacial traps, hysteresis, and mobility. Although the performance is not at the level of state-of-the-art NWFETs grown by conventional methods, which we attribute to substrate interactions, previously proposed strategies offer a clear path for optimization [3]. Furthermore, we implement an amplifier, with a NWFET at cryogenic temperature and a load resistor at room temperature (Fig. 1d), which shows promise for high-frequency operations. Therefore, leveraging scalability and optimization strategies, our results highlight the potential of InAs SAG NWFETs for scalable cryogenic high-frequency nanoelectronics.

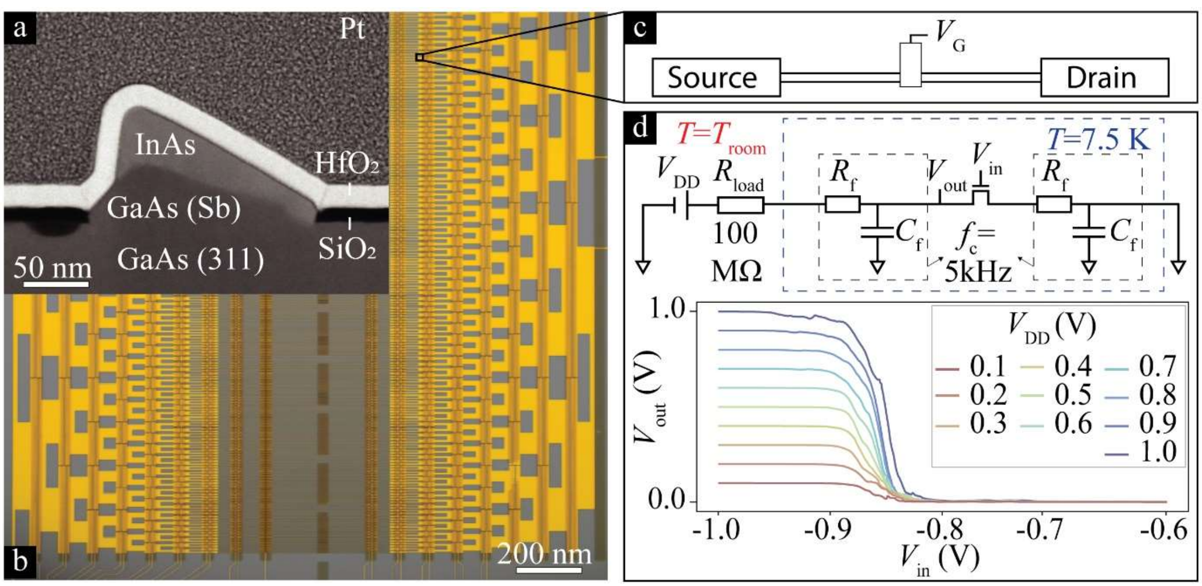

Fig.1. a) Cross-sectional HAADF STEM micrograph of a InAs SAG NW. b) Optical microscope image of a multiplexer circuit based on InAs SAG NWs. c) Schematic representation of a single InAs SAG NWFET. d) SAG NW amplifier circuit: Electrical diagram of a SAG NW amplifier circuit and measurements of the output voltage as a function of input and bias voltages.

References
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